UPPER ATMOSPHERE PHYSICS DATA OBTAINED AT SYOWA STATION IN 1996

Sachihito KAWANA[1], Masayuki KIKUCHI[2], Takeshi SAKANOI[3],
Isamu YUMISASHI[1], and Makoto TAGUCHI[2]

[1] *Communications Research Laboratory, Koganei-shi, Tokyo 184-8795*

[2] *National Institute of Polar Research, Itabashi-ku, Tokyo 173-8515*

[3] *Tohoku University, Sendai-shi, Miyagi 980-8578*

1. Introduction

This data book summarizes upper atmosphere physics data acquired by the 37th Japanese Antarctic Research Expedition (JARE-37) with the "Upper Atmosphere Physics Monitoring (UAPM) System" at Syowa Station in 1996. Observation items are as follows:

1) Geomagnetism :
- H-, D- and Z-components of magnetic variations
- Total force of the geomagnetic field
- H-, D- and Z-components of magnetic pulsations

2) ELF-VLF wave :
- Intensities at 0.35, 0.75, 1.2, 2, 4, 8, 30, 60 and 95 kHz
- Wide-band (0-10 kHz) signal of ELF-VLF emissions

3) Ionosphere :
- Cosmic noise absorption at 30 MHz observed with a broad-beam riometer

4) Aurora :
- All-sky cameras :
  Film type : Panchromatic images recorded on color films
- Scanning photometers :
  Meridian-scanning record at the following three wavelengths
  557.7 nm (OI), 630.0 nm (OI) and 486.1 nm (Hβ)

An outline of the observation system is given in Section 2. Section 3 describes specifications of the observation instruments and the data acquisition systems. Observation periods are also listed in Section 3. Format of the compiled digital data is shown in Section 4. Summary plots in the period of January 1-December 31, 1996 are given in Appendix.

All-sky camera observation data, magnetograms and summary plots of the monitoring data are available to users on request. The request should be addressed to:

World Data Center C2 for Aurora
National Institute of Polar Research

9-10, Kaga 1-chome, Itabashi-ku,
Tokyo 173-8515, Japan.

Digital and analog data described here are available to researchers who will do collaborative studies with the upper atmosphere physics group of NIPR. The request should be addressed to:

Upper Atmosphere Physics Research Division
National Institute of Polar Research
9-10, Kaga 1-chome, Itabashi-ku,
Tokyo 173-8515, Japan.

2. Upper Atmosphere Physics Monitoring (UAPM) System

A real-time digital data acquisition system for upper atmosphere physics observation was constructed at Syowa Station in January 1981 (Sato *et al.*, 1984). Data obtained from the system have been collected and published annually in the JARE Data Reports (Upper Atmosphere Physics) (Sato *et al.*, 1984, 1991 ; Fujii *et al.*, 1985, 1994; Sakurai *et al.*, 1985; Ono *et al.*, 1986, 1993; Yamagishi *et al.*, 1987; Kikuchi *et al.*, 1988; Miyaoka *et al.*, 1990; Kadokura *et al.*, 1992; Yamazaki *et al.*, 1995; Tonegawa *et al.*, 1996; Obara *et al.*, 1996;Arisawa *et al.*, 1997). This report is the 15th of this series.

A block diagram of the system, including other ground observations, is shown in Fig. 1. The sensors for measuring weak natural electromagnetic waves such as ELF-VLF emissions, the three components of ULF magnetic pulsations and cosmic radio noise absorption (CNA) have been placed at a remote station on West Ongul Island, located about 5 km from Syowa Station in order to avoid man-made electromagnetic interference. Data of the magnetic pulsations and CNA are transmitted continuously to Syowa Station by a PCM telemeter in VHF band. Wide-band signals of ELF-VLF emissions are transmitted to Syowa Station through an FM telemeter in UHF band.

At the remote station, the electric power which drives all the instruments has been supplied by a solar battery system with maximum output power of 530 W since February 1985. An additional solar battery system with maximum power of 365 W was installed in January 1987 to reinforce the original battery system. The solar battery system consists of eighteen rechargeable car batteries (200 Ah each), five solar panels and three controllers in total. During winter when no sunlight is available, these batteries are charged manually about once a month by using a 10 kVA diesel-engine dynamo, which was installed in 1992 instead of the previous 16 kVA one.

The fluxgate and proton magnetometer sensors are placed at Syowa Station on East Ongul Island, about 150 m apart from the Data Processing Building. All the auroral photometric instruments are placed on the roof of the building, and the data acquisition facilities are installed inside the building. All the outputs obtained from the observation instruments except the auroral

photometric ones are transferred to the matrix terminal board and then recorded with pen recorders, analog data recorders and a computer system. These data have been recorded simultaneously with two sets of the TEAC DR-200 digital data logger systems since January 1987. An 8 mm video tape recorder is used to record wide-band VLF emissions, and 24-hour data can be stored on one volume of 8 mm video tape.

Universal time (UT) is supplied from a precise time-keeping system. This system consists of an GPS satellite timing receiver, a quartz frequency standard with a stability of 2×10^{-11}/day, and time code generators. The time code generators supply the IRIG-A, -B and slow codes for analog data recorders and the 36-bit BCD code for the digital recording systems, respectively. The absolute accuracy of this system is estimated to be about 1 ms.

3. Specifications of Instruments

3.1. Geomagnetism

(1) *Magnetogram*

Magnetic variations were measured by a three-axis fluxgate magnetometer. Full scale ranges were +1250 to -3750 nT for H-component and ± 2500 nT for D- and Z- components, respectively, with the frequency response of DC–2 Hz and noise levels less than 0.5 nT. The magnetometer data were recorded in digital form at the sampling rate of 1 Hz. The H-component data were also recorded on a chart recorder and an R-950L long-term analog data recorder.

(2) *Total force of the geomagnetic field*

Due to the prolonged trouble with the proton magnetometer since January 1991, the total force observations were made only about once per month in 1996, using the other portable proton magnetometer, which was unable to be linked with the UAPM system. The results are listed in Table 1.

(3) *ULF magnetic pulsations*

The H-, D-, and Z-components of ULF magnetic pulsations are detected by three sets of search coil magnetometers. The search coil sensors have copper wires (0.4 mmϕ, 40000 turns each) wound around permalloy cores (1 cm in diameter × 100 cm in length). Measurable intensity range of the magnetometer is 0.001–5 nT/s and the frequency response is 0.001–3 Hz. The search coil magnetometers are installed at the remote station on West Ongul Island. The output signals transmitted by the PCM telemeter are recorded on an R-950L long-term analog data recorder, a chart recorder and a digital data recorder. The sampling frequency of the digital data is 1 Hz for each component.

(4) *Base line of the magnetic field and K-index*

Base line values of the magnetic field were observed about once per month during a

magnetically quiet day. K-indices are calculated for every 3-hour interval measuring the maximum deviations of the H- and D-component magnetic fields from the quiet-day baselines. The definition of the K-indices at Syowa Station is as follows:

K-index		Deviation	K-index		Deviation
0	:	0 - 25 nT	5	:	350 – 600 nT
1	:	25 – 50	6	:	600 – 1000
2	:	50 – 100	7	:	1000 – 1660
3	:	100 – 200	8	:	1660 – 2500
4	:	200 – 350	9	:	2500 and more

The ordinary magnetogram is also available on chart papers with a recording speed of 5 cm/hr. The sensitivity of each component on the chart papers is about 100 nT/cm. Table 2 gives the baseline values and K-indices at Syowa Station in February 1996 – January 1997. Inquiries or requests for the data copies of the magnetic field measurements should be addressed to World Data Center C2 for Aurora in NIPR.

3.2. ELF-VLF waves

The natural ELF-VLF wave receiving system at the remote station has consisted of a triangle-shaped three turn loop antenna (10 m in height, 20 m in the bottom side), a pre-amplifier and a main amplifier with gains of 60 and 40 dB, respectively. The ELF-VLF wave intensities at the frequency bands of 0.35, 0.75, 1.2, 2, 4, 8, 30, 60, 95 kHz were obtained from wide band waveforms using a 9-channel filter bank and detectors. The ELF-VLF emissions within the intensity range of 10^{-17} to 10^{-13} W/m^2 Hz were detectable with this system. These data were recorded continuously in digital form at the sampling rate of 1 Hz. Some of the wide-band ELF-VLF signals up to 10 kHz were recorded on 8 mm video tape recorders. The wide-band recording was executed during 900 - 1300 UT on Sunday - Friday.

3.3. Ionosphere

Cosmic noise absorption at 30 MHz was observed with a broad-beam riometer, which has been installed at the remote station on West Ongul Island since 1981. Its beam half-width is 60°. Used receiver is made by La Jolla Science, and bandwidth and time constant are 150 kHz and 0.25 s, respectively. The riometer data were recorded in digital form at the sampling rate of 1 Hz in the UAPM system.

Data of ionospheric vertical sounders, broad-beam riometers (20 and 30 MHz), HF field strength receivers (8 and 10 MHz) and the VHF auroral radar (50 and 112 MHz) were recorded with other observation systems at Syowa Station, and the observational results have been published in another JARE Data Report (Ionosphere). Inquiries and requests for the data copies are to be addressed to:

World Data Center C2 for Ionosphere
Communications Research Laboratory
Ministry of Posts and Telecommunications
2-1, Nukui-Kitamachi 4-chome, Koganei-shi,
Tokyo 184-8795, Japan.

3.4. Aurora

(1) *All-sky camera*

All-sky observation of aurora was made by traditional film-type camera with a fish-eye lens of 8 mm F2.8. KODAK-EASTMAN 5226, ISO-500, 400 ft, 35 mm color films were used. An observation list for the film-type is given in Table 3. Inquiries or requests for the all-sky data should be addressed to World Data Center C2 for Aurora in NIPR.

(2) *Meridian-scanning photometer*

Auroral emissions at the wavelengths of 557.7 nm (OI), 630.0 nm (OI) and 486.1 nm (Hβ) were observed by a meridian-scanning photometer installed in 1987. The interference filter for Hβ was tilted with 1 s period, measuring the Doppler effect of the auroral Hβ emission. The field of view of the photometer is 3° for OI 557.7 nm and 630.0 nm, and 5° for Hβ. A scan along a meridian from the poleward horizon to the equatorward horizon requires 30 s. Observations were carried out during 107 clear nights from March 14 until October 15 in 1996. Calibration using a standard light source was executed at every observation night. The meridian-scanning photometer data were recorded with a digital data logger (TEAC DR-200) at a sampling frequency of 10-25 Hz through a line-approximate logarithmic amplifier, and monitored with a pen-recorder (6 ch RECTI-GRAPH). Due to a trouble in the instrument, both scanning and tilting angle data were not recorded.

4. Compiled Digital Tape Format

Data have been digitally recorded continuously since 1981. A similar recording system has been used in Iceland for the geomagnetic conjugate observations. The specifications of the compiled digital tapes are as follows:

Tracks	: 9
Record density	: 6250 BPI
Record format	: FB
Block length	: 28848 bytes
Logical record length	: 48 bytes
Label	: Non-label

Filing : Multi-file (1 file/day)

24 kinds of upper atmospheric data are recorded every 1 s in the following sequence:

Word No.	Observation item	Word No.	Observation item
1	H-component of magn. field	13	VLF 8 kHz
2	D-component of magn. field	14	VLF 30 kHz
3	Z-component of magn. field	15	VLF 60 kHz
4	H-component of ULF waves	16	VLF 95 kHz
5	D-component of ULF waves	17	NA
6	Z-component of ULF waves	18	NA
7	CNA (30 MHz)	19	NA
8	VLF 350 Hz	20	NA
9	VLF 750 Hz	21	NA
10	VLF 1.2 kHz	22	NA
11	VLF 2 kHz	23	NA
12	VLF 4 kHz	24	NA

Words 17-24 are dummy words. Each word, 12 bit A/D converted value, is recorded in the 2 byte binary form of signed 2's complement. A set of these 24 words makes a logical record of 48 bytes; the 10-min data make a block of 28848 bytes. A file contains one day of data (144 blocks) and a volume contains one month of data (28-31 files), as shown in Fig. 2. At the beginning of each block, the starting time of the observation period is written in the following format (48 bytes).

Sequence	Item	
1	Year	(2 bytes)
2	Total day	(2 bytes)
3	Hour	(2 bytes)
4	Minute	(2 bytes)
5	Station code	(4 bytes)
6	Space	(36 bytes)

The magnetic field data recorded on a compiled tape can be transformed to physical quantities by the following relations:

H-component of the geomagnetic field variation (nT) = DATA*2500/2048 – 1250
D- and Z-component of the geomagnetic field variation (nT) = DATA*2500/2048
H-component of ULF waves (nT/s) = DATA/141
D-component of ULF waves (nT/s) = DATA/158

Z-component of ULF waves (nT/s) = DATA/316

For CNA and VLF data, individual calibration values are required to obtain physical values from the recorded data. Inquiries on these calibration values should be addressed to the Upper Atmosphere Physics Research Division of NIPR. For more detailed information on the compiled data, see Uchida *et al.* (1988). These compiled data are also recorded on an Optical Disk (OD) at the sampling rate of 0.5 Hz together with the data from three Icelandic stations for conjugate studies. One volume of the OD can store the data obtained at the four stations during one year. Softwares to handle the OD data are also available to researchers. Details of the OD conjugate data base are described in Yamagishi (1990).

A computer system of the Information Science Center is available to collaborative researchers of NIPR. The center has also been providing various kinds of software such as tape-to-tape copy, displays and spectrum analysis program to the researchers.

Acknowledgments

We would like to acknowledge all the members of the 37th Japanese Antarctic Research Expedition (JARE-37) for their support to the upper atmosphere physics observations at Syowa Station. The publication of this report was supported by the Upper Atmosphere Physics Research Division, WDC-C2 for Aurora and the Information Science Center of the National Institute of Polar Research.

References

Arisawa, T., Kato, Y., Otaka, K., Inamori, Y., Kaneko, M. and Taguchi, M. (1997): Upper atmosphere physics data obtained at Syowa Station in 1995. JARE Data Rep., **225** (Upper Atmos. Phys. 15), 204p.

Fujii, R., Sato, N. and Fukunishi, H. (1985): Upper atmosphere physics data, Syowa Station, 1982. JARE Data Rep., **105** (Upper Atmos. Phys. 2), 266p.

Fujii, R., Kotake, N., Murata, I., Nozaki, K., Umetsu, M., Makita, K., Minatoya, H. and Yukimatu, A. (1994): Upper atmosphere physics (UAP) data obtained at Syowa and Asuka Stations in 1991. JARE Data Rep., **193** (Upper Atmos. Phys. 11), 208p.

Kadokura, A., Uchida, K., Kurihara, N., Kimura, K., Okamura, H., Ariyoshi, H., Yukimatsu, A. and Ejiri, M. (1992): Upper atmosphere physics data, Syowa and Asuka Stations, 1989. JARE Data Rep., **171** (Upper Atmos. Phys. 9), 335p.

Kikuchi, T., Ohwada, T., Oginasa, T., Uchida, K., Sakurai, H., Yamagishi, H. and Sato, N. (1988): Upper atmosphere physics data, Syowa Station, 1986. JARE Data Rep., **138** (Upper Atmos. Phys. 6), 276p.

Miyaoka, H., Uchida, K., Mukai, H., Saito, H., Akamatsu, J., Shibuya, K., Sakai, R., Ayukawa, M. and Sato, N. (1990): Upper atmosphere physics data, Syowa and Asuka Stations, 1987. JARE Data Rep., 159 (Upper Atmos. Phys. 7), 306p.

Obara, N., Wakino, Y., Kubota, M., Iwasaki, K., Nishimura, H. and Kadokura, A. (1996): Upper atmosphere physics data obtained at Syowa Station in 1994. JARE Data Rep., 209 (Upper Atmos. Phys. 14), 208p.

Ono, T., Tsunomura, S., Ejiri, M., Fujii, R. and Sato, N. (1986): Upper atmosphere physics data, Syowa Station, 1984. JARE Data Rep., 118 (Upper Atmos. Phys. 4), 271p.

Ono, T., Nakajima, H., Satoh, M., Ohtaka, K., Kawahara, M. and Kumade, A. (1993): Upper atmosphere physics data, Syowa and Asuka Stations, 1990. JARE Data Rep., 186 (Upper Atmos. Phys. 10), 222p.

Sakurai, H., Shibasaki, K., Fujii, R. and Sato, N. (1985) : Upper atmosphere physics data, Syowa Station, 1983. JARE Data Rep., 108 (Upper Atmos. Phys. 3), 212p.

Sato, N., Fujii, R., Fukunishi, H. and Nakajima, D. (1984): Upper atmosphere physics data, Syowa Station, 1981. JARE Data Rep., 93 (Upper Atmos. Phys. 1), 206p.

Sato, N., Uchida, K., Saka, O., Yamaguchi, K., Iguchi, S., Aoki, T. and Miyaoka, H. (1991): Upper atmosphere physics data, Syowa and Asuka Stations, 1988. JARE Data Rep., 169 (Upper Atmos. Phys. 8), 212p.

Tonegawa, Y., Rokuyama, K., Makita, Y., Yang, H., Kadokura, A. and Sato, N. (1996): Upper atmosphere physics data obtained at Syowa Station in 1993. JARE Data Rep., 208 (Upper Atmos. Phys. 13), 202p.

Uchida, K., Tonegawa, Y., Fujii, R. and Sato, N. (1988): Computer compilatory process of the data acquired by the conjugate observation system in Iceland. Nankyoku Shiryô (Antarct. Rec.), 32, 238-257 (in Japanese with English abstract).

Yamagishi, H. (1990): Development of Optical Disk data base system for Syowa Station-Iceland geomagnetically conjugate observation. Nankyoku Shiryô (Antarct. Rec.), 34, 242-262 (in Japanese with English abstract).

Yamagishi, H., Ayukawa, M., Matsumura, S., Sakurai, H. and Sato, N. (1987): Upper atmosphere physics data, Syowa Station, 1985. JARE Data Rep., 128 (Upper Atmos. Phys. 5), 272p.

Yamazaki, I., Takahashi, Y., Mineno, H., Kamata, M., Ogawa, Y. and Kadokura, A. (1995): Upper atmosphere physics data obtained at Syowa Stations in 1992. JARE Data Rep., 205 (Upper Atmos. Phys. 12), 207p.

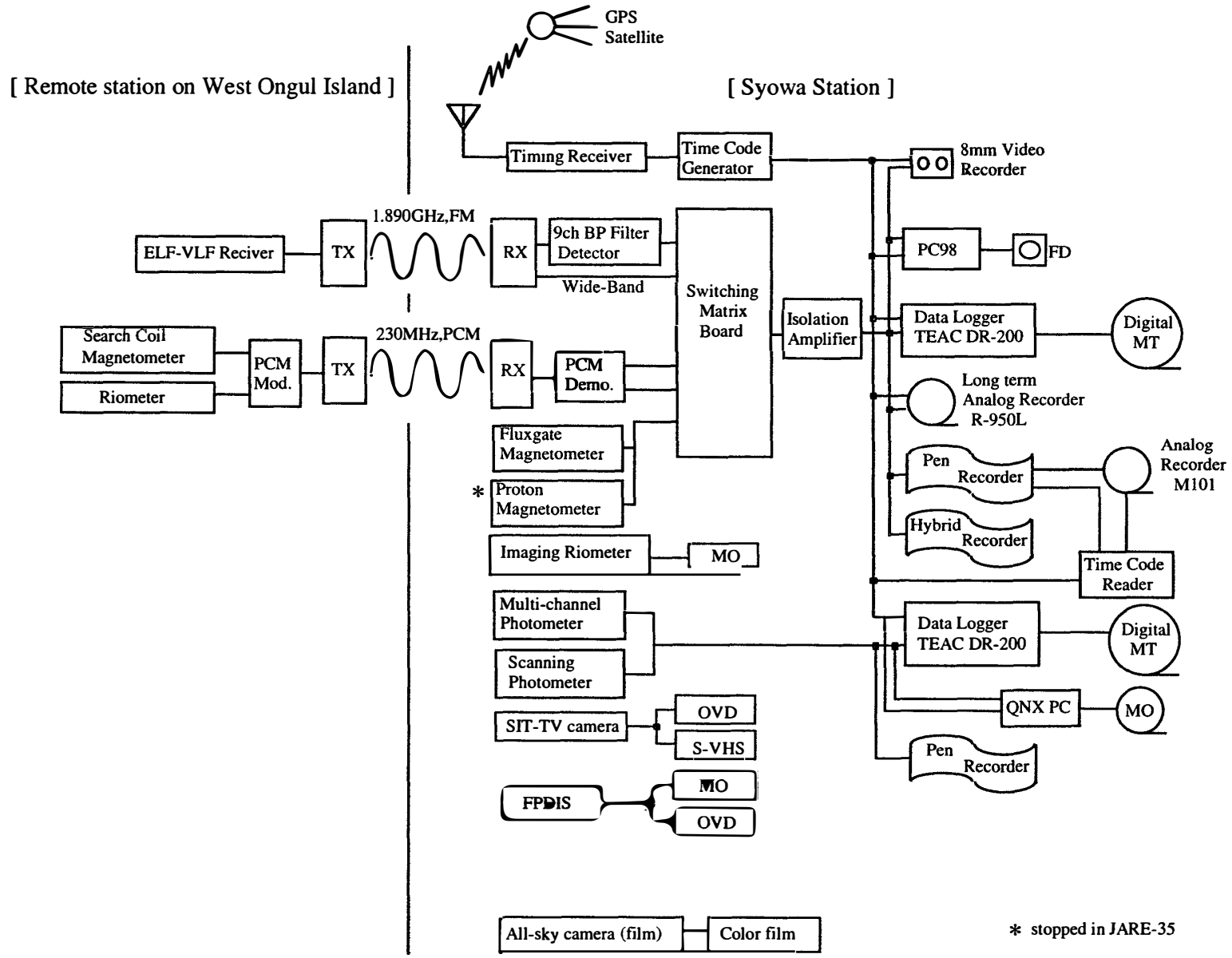

Fig. 1. Block diagram of the "Upper Atmosphere Physics" monitoring system at Syowa Station in 1996.

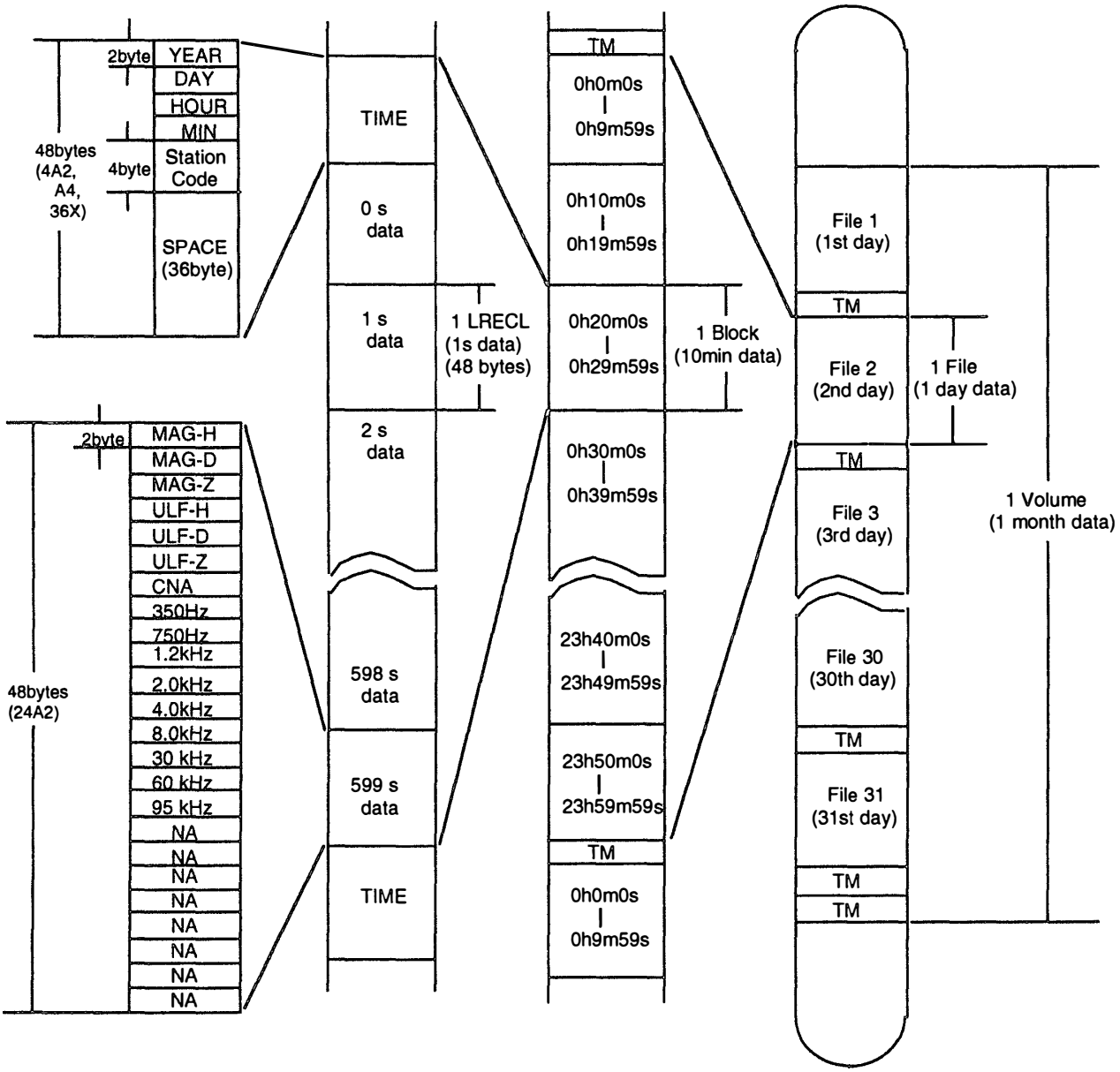

Fig. 2. The structure of the compiled digital tape format for Syowa Station in 1996.

Table 1. Baseline values of the geomagnetic field at Syowa Station in February 1996–January 1997.

DATE	TIME(UT) hh:mm	TOTAL (nT)	HOLIZON-TAL (nT)	VERTICAL (nT)	DECLI. (deg:min)	DIP ANGLE (deg:min)
1996 03/02	10:48	43592.8	19124.3	-39173.9	-47:56.4	-63:58.7
	10:58	43593.8	19123.9	-39175.3	-47:55.8	-63:58.8
	11:21	43595.0	19125.2	-39175.9	-47:55.8	-63:58.7
	11:33	43594.7	19123.1	-39176.6	-47:55.9	-63:58.9
mean	11:10	43594.1	19124.1	-39175.4	-47:56.0	-63:58.8
1996 04/01	11:17	43617.3	19136.5	-39195.2	-47:54.2	-63:58.6
	11:29	43621.3	19137.1	-39199.3	-47:53.9	-63:58.7
	11:53	43611.6	19132.9	-39190.6	-47:54.1	-63:58.7
	12:05	43617.5	19132.1	-39197.6	-47:54.6	-63:59.0
mean	11:41	43616.9	19134.7	-39195.7	-47:54.2	-63:58.7
1996 04/27	11:17	43578.5	19132.0	-39154.2	-47:55.9	-63:57.5
	11:29	43580.1	19131.6	-39156.2	-47:55.6	-63:57.6
	11:55	43585.7	19138.6	-39159.0	-47:55.5	-63:57.2
	12:12	43586.9	19106.1	-39176.2	-47:56.1	-64: 0.1
mean	11:44	43582.8	19134.1	-39156.5	-47:55.8	-63:58.1
1996 06/02	07:46	43582.2	19150.6	-39149.2	-47:54.8	-63:56.0
	07:53	43580.1	19147.1	-39148.6	-47:55.0	-63:56.2
	08:08	43582.2	19150.9	-39149.1	-47:55.4	-63:56.0
	08:21	43582.7	19149.1	-39150.5	-47:55.1	-63:56.2
mean	08:03	43581.8	19149.4	-39149.4	-47:55.1	-63:56.1
1996 07/01	08:59	43578.6	19175.1	-39133.3	-48: 1.0	-63:53.7
	09:12	43578.3	19158.2	-39141.2	-47:59.9	-63:55.2
	09:30	43577.6	19157.9	-39140.6	-47:59.2	-63:55.2
	09:39	43575.2	19152.0	-39140.7	-47:59.3	-63:55.6
mean	09:20	43577.4	19160.8	-39138.9	-47:59.8	-63:54.9
1996 08/06	11:15	43576.2	19145.0	-39145.3	-47:56.5	-63:56.3
	11:28	43572.6	19142.0	-39142.8	-47:56.0	-63:56.4
	11:46	43577.4	19145.3	-39146.5	-47:56.2	-63:56.3
	11:55	43575.7	19143.6	-39145.4	-47:56.0	-63:56.4
mean	11:35	43575.5	19144.0	-39145.0	-47:56.2	-63:56.3

DATE	TIME(UT) hh:mm	TOTAL (nT)	HOLIZON-TAL (nT)	VERTICAL (nT)	DECLI. (deg:min)	DIP ANGLE (deg:min)
1996 09/03	11:15	43572.8	19147.3	-39140.4	-47:60.0	-63:55.9
	11:28	43573.2	19142.4	-39143.3	-48: 0.0	-63:56.4
	11:47	43568.8	19136.7	-39141.1	-47:59.0	-63:56.7
	12:00	43573.6	19138.0	-39145.9	-47:59.0	-63:56.8
mean	11:37	43572.1	19141.1	-39142.7	-47:59.5	-63:56.5
1996 10/01	10:47	43572.0	19177.8	-39124.6	-47:60.0	-63:53.2
	10:56	43574.3	19149.8	-39140.8	-47:59.6	-63:55.8
	11:17	43573.2	19149.3	-39139.8	-47:59.8	-63:55.8
	11:24	43574.6	19148.8	-39141.6	-47:59.7	-63:55.9
mean	11:05	43573.5	19156.4	-39136.7	-47:59.8	-63:55.2
1996 11/02	09:39	43557.3	19137.3	-39128.0	-48: 4.3	-63:56.2
	09:50	43556.8	19138.4	-39126.9	-48: 3.8	-63:56.1
	10:05	43557.8	19135.8	-39129.3	-48: 3.2	-63:56.4
	10:15	43558.4	19132.6	-39131.5	-48: 2.5	-63:56.7
mean	09:57	43557.5	19136.0	-39128.9	-48: 3.5	-63:56.3
1996 11/29	11:01	43552.9	19141.3	-39121.2	-48: 0.3	-63:55.7
	11:08	43551.9	19135.4	-39122.9	-47:59.4	-63:56.2
	11:26	43552.8	19135.9	-39123.8	-47:59.2	-63:56.2
	11:35	43557.8	19138.3	-39128.1	-47:58.8	-63:56.2
mean	11:18	43553.9	19137.7	-39124.0	-47:59.4	-63:56.0
1996 12/26	11:05	43545.3	19137.9	-39114.3	-47:59.2	-63:55.7
	11:17	43549.1	19139.6	-39117.8	-47:59.1	-63:55.7
	11:34	43555.3	19145.8	-39121.7	-47:59.0	-63:55.4
	11:41	43555.5	19145.8	-39121.8	-47:58.8	-63:55.4
mean	11:23	43551.3	19142.3	-39118.9	-47:59.1	-63:55.5
1997 01/31	11:14	43547.8	19140.2	-39116.0	-47:59.8	-63:55.6
	11:30	43546.2	19140.6	-39114.0	-47:59.1	-63:55.5
	11:50	43546.5	19143.0	-39113.2	-47:59.9	-63:55.3
	12:03	43548.2	19144.6	-39114.3	-47:60.0	-63:55.2
mean	11:38	43547.2	19142.1	-39114.4	-47:59.7	-63:55.4

Table 2. K-indices at Syowa Station in February 1996–January 1997.

	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	JANUARY
1	4321 1333	4310 0143	4422 1223	2322 2132	3220 0002	3210 0036	5442 2236	4311 1122	3310 0033	3110 0003	1122 1102	3111 1112
2	5422 2322	3100 1012	310 1024	2211 2221	2210 0032	4311 0004	6333 2212	3411 1113	1221 1224	1111 0012	1211 1443	2221 1222
3	2211 1112	4321 0333	2101 1115	2311 0113	1111 1003	4522 2112	4322 2134	0011 1002	4442 2254	1111 0121	4321 2213	3111 0113
4	1221 1225	3431 1243	5421 3324	5410 1255	2200 0112	5631 1133	2222 1124	2111 1015	2111 1214	4323 2334	3211 3324	2221 0123
5	3421 1223	3321 1122	4111 1103	6331 1102	0111 0024	6632 2120	3421 1112	3321 1115	2211 0011	3221 1234	1121 1001	211X XXXX
6	3321 0111	2012 2201	3111 0000	3321 1023	2622 2222	2211 1111	4301 2243	5112 0004	3211 0000	4422 1135	1111 1012	XX11 1110
7	3321 2135	2110 1110	1100 1110	4300 1003	0001 0000	3441 1200	2101 0154	3321 1104	1111 1122	2221 1122	1221 1233	4572 3331
8	3321 1223	1433 1002	0100 1004	5521 1113	0001 1022	1232 1215	3300 0002	4421 1100	3222 1354	2112 1111	1221 0112	4421 1122
9	4222 1224	4421 0224	5331 1245	4410 1100	1000 0020	3210 0000	3001 0223	1212 2214	3533 2356	2321 2334	1211 2126	4121 1222
10	2421 2446	4231 2156	4422 0100	2311 0023	1311 1101	1110 0002	5421 0001	7644 2244	5521 2222	4422 1112	5543 2444	XXXX X333
11	6634 2345	7652 3136	5321 1116	1320 1110	0010 0025	1000 0033	2200 0003	5643 4335	3111 2333	2111 0221	4233 3234	4432 3222
12	3533 2434	4443 2236	6533 3465	0101 0014	5120 0000	2432 1255	2210 0003	7554 3445	5522 3235	5322 2214	3322 2323	2242 2234
13	5432 2353	6533 3335	2211 1226	4442 2125	0210 0000	4101 1120	3301 2001	6432 2256	5634 2225	3212 1264	3221 2221	3422 2212
14	4332 2354	5531 1125	4534 3137	5422 1134	2200 1000	1210 0015	3322 2235	5322 1323	6423 2214	6223 3344	1122 2233	1221 2122
15	5321 1044	5411 0121	7433 2235	2133 2233	0100 0034	3220 1134	4112 2113	4232 3353	3221 1122	4323 4322	3422 3465	2221 2110
16	3321 2314	5522 1110	3321 3225	4332 1253	4400 0023	2100 1123	3221 1333	5633 3435	4221 2333	2121 1122	4322 3225	2221 1001
17	5541 1224	5542 2235	6633 2467	5333 1123	4511 0124	5522 1214	5523 2113	4511 1134	1211 1124	4422 1245	2332 2331	0111 0113
18	3222 2334	53 2 1133	6643 3226	1100 1000	1021 0016	3112 0212	1121 1122	5133 3345	6643 2335	5532 3242	2221 1221	5421 0122
19	3321 1133	3433 2346	4544 3466	0011 1144	6432 2123	3212 0003	3211 1102	2122 2444	6633 4566	4422 3234	1211 1002	2222 1433
20	4421 2234	5643 3366	6533 3244	5212 2225	4311 1100	5512 2223	3123 3220	6554 3347	6532 3234	3222 1366	XXXX XXXX	2121 2334
21	2221 1112	5433 3556	6433 3255	5322 2222	3011 2102	3311 2133	1222 2112	6643 2455	3322 1333	5221 1125	2222 2333	3322 3432
22	4541 1234	4333 2435	4621 2213	2011 1033	3100 0000	4321 1122	3300 0212	6453 4424	5533 4447	3211 2201	3211 3445	3321 1123
23	4522 3435	5511 1244	6443 1233	3100 0101	1100 1110	2321 1111	2443 2123	5654 4445	7844 1334	1221 1232	4422 1112	4221 1101
24	5632 2354	6422 2347	3301 1333	1311 1012	4311 1032	1111 0013	3321 1125	5232 2123	5422 2333	2222 3325	2321 1211	1121 1124
25	5432 2555	5452 3323	3411 1112	2410 0134	1000 0002	2101 0022	5433 3235	1423 2214	3332 2122	3422 1123	2222 2213	2221 0033
26	6422 3235	5432 3233	4110 0000	5332 2102	2100 0002	3310 1113	5433 1125	4632 3456	4221 1111	3222 3223	1121 1124	4222 3456
27	3321 2255	5532 1214	3111 1024	0011 1455	1012 1112	2111 0000	5522 2224	5433 1215	2211 1014	5422 1124	2211 0112	4422 2245
28	3521 2114	3542 2224	3112 0010	4221 1000	5321 0024	2100 1354	4322 2245	3652 2334	5432 2344	4422 3323	3122 1112	4633 3555
29	1221 2254	4321 1124	1232 1100	0111 1113	4200 0133	2321 1102	7754 4337	3321 1131	5522 3245	2111 2333	1111 1135	5222 2134
30		2211 1114	4311 2112	2122 2112	4232 0003	3421 1033	7432 2334	1221 1101	3322 2555	3211 1112	5422 3223	5321 3435
31		3111 0215		3211 0024		5423 3324	5533 2222		3321 1223		3321 1223	4511 1145

Table 3. Observation periods of a 35 mm all-sky camera at Syowa Station in 1996.

Date	Hours (Universal Time)									K-Index	
	h	m	s	h	m	s	h	m	s		
MAR. 10				19	00	00	-23	30	00	4231	2156
13				19	35	00	-21	00	00	6533	3335
14				19	00	00	-00	45	00	5531	1125
16				18	30	00	-19	40	00	5522	1110
18				18	10	00	-22	43	00	53 2	1133
19							18	10	00	3433	2346
20	-01	00	00				18	00	00	5643	3366
21	-01	00	00							5433	3556
24							23	40	00	6422	2347
25	-01	30	00							5452	3323
29							17	30	00	4321	1124
30	-01	30	00							2211	1114
APR. 1				17	45	00	-21	33	00	4422	1223
4							23	03	00	5421	3324
5	-02	30	00	16	40	00	-20	10	00	4111	1103
8							20	03	00	0100	1004
9	-02	40	00	16	25	00	-23	31	00	5331	1245
12							18	41	00	6533	3465
13	-03	00	00				21	43	00	2211	1226
14	-03	00	00							4534	3137
17							22	02	00	6633	2467
18	-03	10	00				22	05	00	6643	3226
19	-03	10	00	16	05	00	-19	05	00	4544	3466
19							22	58	00		
20	-03	10	00							6533	3244
21							17	20	00	6433	3255
22	-03	15	00				16	06	00	4621	2213
23	-00	50	00				16	12	00	6443	1233
24	-03	20	00				15	47	00	3301	1333
25	-03	03	00							3411	1112
29							23	18	00	1232	1100
30	-01	00	00							4311	2112
MAY. 1							15	15	00	2322	2132
2	-00	45	00				16	40	00	2211	2221
3	-00	03	00							2311	0113

Date	Hours (Universal Time)									K-Index	
	h	m	s	h	m	s	h	m	s		
MAY. 4							17	50	00	5410	1255
5	-04	00	00				14	30	00	6331	1102
6	-04	00	00				17	40	00	3321	1023
7	-03	38	00							4300	1003
9							15	52	00	4410	1100
10	-01	31	00				15	53	00	2311	0023
11	-04	00	00							1320	1110
13							14	10	00	4442	2125
14	-03	08	00				22	04	00	5422	1134
15	-04	00	00				15	00	00	2133	2233
16	-04	30	00				13	45	00	4332	1253
17	-02	16	00				14	45	00	5333	1123
18	-04	30	00				14	45	00	1100	1000
19	-03	51	00							0011	1144
21							22	52	00	5322	2222
22	-04	30	00							2011	1033
24							21	11	00	1311	1012
25	-04	30	00				14	00	00	2410	0134
26	-04	30	00							5332	2102
30				14	22	00	-20	39	00	2122	2112
31				13	30	00	-19	22	00	3211	0024
JUN. 1				13	30	00	-15	22	00	3220	0002
2							13	40	00	2210	0032
3	-00	49	00							1111	1003
5							13	33	00	0111	0024
6	-05	00	00				13	30	00	2622	2222
7	-05	05	00				13	30	00	0001	0000
8	-05	00	00				13	30	00	0001	1022
9	-02	58	00							1000	0020
12				16	05	00	-18	43	00	5120	0000
13							13	30	00	0210	0000
14	-04	10	00				18	50	00	2200	1000
15	-05	20	00				13	30	00	0100	0034
16	-05	20	00				14	01	00	4400	0023
17	-05	20	00				13	30	00	4511	0124
18	-01	00	00				14	15	00	1021	0016
19	-05	20	00				17	10	00	6432	2123
20	-05	20	00							4311	1100

Date	Hours (Universal Time)									K-Index	
	h	m	s	h	m	s	h	m	s		
JUN. 20				13	30	00	-17	00	00	4311	1100
21							13	50	00	3011	2102
22	-05	20	00				13	30	00	3100	0000
23	-05	20	00				13	30	00	1100	1110
24	-03	24	00							4311	1032
25							21	14	00	1000	0002
26	-05	20	00				13	30	00	2100	0002
27	-05	20	00				13	30	00	1012	1112
28	-05	20	00				13	30	00	5321	0024
29	-01	08	00							4200	0133
JUL. 1							14	00	00	3210	0036
2	-05	20	00				20	33	00	4311	0004
3	-05	20	00				13	30	00	4522	2112
4	-04	03	00							5631	1133
6							15	30	00	2211	1111
7	-03	23	00				14	17	00	3441	1200
8	-05	10	00							1232	1215
11							21	53	00	1000	0033
12	-05	10	00							2432	1255
13							13	50	00	4101	1120
14	-05	10	00							1210	0015
17				13	50	00	-21	20	00	5522	1214
19				13	50	00	-21	50	00	3212	0003
20							14	00	00	5512	2223
21	-05	10	00				14	00	00	3311	2133
22	-05	10	00				14	00	00	4321	1122
23	-04	40	00	01	55	00	-02	45	00	2321	1111
31							14	40	00	5423	3324
AUG. 1	-00	33	00				14	40	00	5442	2236
2	-04	20	00				14	40	00	6333	2212
3	-04	20	00				14	40	00	4322	2134
4	-04	20	00				14	40	00	2222	1124
5	-04	10	00				14	40	00	3421	1112
6	-03	52	00							4301	2243
7				14	45	00	-19	19	00	2101	0154
9							17	55	00	3001	0223
10	-04	10	00							5421	0001

Date	Hours (Universal Time)									K-Index	
	h	m	s	h	m	s	h	m	s		
AUG. 11							15	00	00	2200	0003
12	-03	08	00	15	15	00	-22	05	00	2210	0003
13							22	40	00	3301	2001
14	-03	40	00				15	10	00	3322	2235
15	-03	40	00							4112	2113
17				19	24	00	-21	02	00	5523	2113
18							16	50	00	1121	1122
19	-03	20	00				16	05	00	3211	1102
20	-03	20	00				16	10	00	3123	3220
21	-03	20	00				16	00	00	1222	2112
22	-03	20	00				16	20	00	3300	0212
23	-03	20	00				16	28	00	2443	2123
24	-03	10	00				16	20	00	3321	1125
25	-00	30	00				16	20	00	5433	3235
26	-02	50	00	16	57	00	-18	49	00	5433	1125
27				16	45	00	-22	45	00	5522	2224
29							17	11	00	7754	4337
30	-02	50	00				20	15	00	7432	2334
31	-02	30	00				17	05	00	5533	2222
SEP. 1	-02	10	00				17	10	00	4311	1122
2	-02	30	00				16	40	00	3411	1113
3	-02	30	00							0011	1002
4	-02	20	00				16	55	00	2111	1015
5	-02	10	00				21	25	00	3321	1115
6	-02	10	00				16	50	00	5112	0004
7	-02	10	00				16	40	00	3321	1104
8	-02	10	00							4421	1100
9				17	05	00	-23	18	00	1212	2214
10							16	50	00	7644	2244
11	-02	00	00				17	45	00	5643	4335
12	-01	50	00				17	15	00	7554	3445
13	-01	50	00				17	15	00	6432	2256
14	-01	50	00	17	15	00	-23	21	00	5322	1323
15				19	40	00	-23	50	00	4232	3353
17							17	30	00	4511	1134
18	-01	20	00							5133	3345
19				18	47	00	-19	19	00	2122	2444

Date	Hours (Universal Time)									K-Index	
	h	m	s	h	m	s	h	m	s		
SEP. 24							18	16	00	5232	2123
25	-00	20	00							1423	2214
27				18	50	00	-21	20	00	5433	1215
30				19	11	00	-23	20	00	1221	1101
OCT. 1				19	17	00	-23	20	00	3310	0033
2				18	46	00	-23	20	00	1221	1224
3				18	45	00	-20	24	00	4442	2254
7				19	00	00	-23	10	00	1111	1122
9				20	37	00	-23	00	00	3533	2356
13				19	20	00	-23	00	00	5634	2225
14				19	30	00	-21	25	00	6423	2214
15				19	30	00	-21	15	00	3221	1122